Abstract
The auction system in the wind energy sector is driving prices down worldwide and all competitors are focusing on maximizing the production of energy as well as reducing the investment required.

Higher towers and more powerful turbines lead to an increase of foundation loads, hence the increase in higher volumes of concrete on regular shallow slab foundations. Nowadays, values around 400 m³ are common and therefore efforts are being made to reduce the concrete volume and reinforcing steel weight in WTG foundations. Even so, most of the proposed variations have not had a significant penetration in the market since, when effective material savings resulted in much higher excavation costs as well as longer construction schedules.

The precast braced foundation concept comes as a result of the ESTECO ENERGIA tower’s extensive experience in the WTG foundation sector –over 1,500 WTG foundations designed and built together with their pioneering experience as precast concrete tower designers –1,000 WTG designed towers. This background has led to a patented and certified solution (dWV-G1 and tDV-V1G1), 100% owned solely by ESTECO.

The foundation design is inspired by the path that turbine loads take from the tower base to the ground. With a skewer shape concrete structure partially prefabricated, the foundation uses the natural soil as a deadweight self-weight restricting the amount of concrete required. Additionally, the introduction of precast elements allows the industrialization of both manufacturing and assembling stages. These aspects are leading to a robust and solid solution that significantly reduces the Cost of Energy.

Objectives
The main objective of this solution is to achieve the significant reduction of the Cost of Energy, being what all agents involved in this market are actively pursuing. This achievement comes from a double source explained in the following paragraphs.

The precast braced foundation increases the Energy production by 1.5% to 2.5%, depending on the wind, as a result of the hub height tilt gain, up to 6 metres, provided to the turbine with respect to a traditional foundation.

The precast braced foundation reduces the foundation execution cost (as the range of 30%-55%) due to a reduction of 30%-40% on concrete and steel quantities compared to a conventional foundation.

Additionally, it is a new variable that is already taking place in the analysis optimization of energy production versus overall windfarm investments. Shorter and cheaper towers combined with this foundation compete with higher and more expensive towers to get the same energy production.

Finally, it is considered to be a risk mitigation agent on construction-quality standards since it has prefabricated (pre-cast) elements, the anchor cage is required at a later stage and the concrete volumes required per construction phase are reduced considerably avoiding risks coming from concrete supply unexpected problems.

Method
Stage 1: Excavation and blind-concrete casting
All these operations are carried out in the same way as in a conventional/foundation solution.

Stage 2: Lower reinforcing steel and pedestal framework arrangement
Reinforcing steel can be manufactured straight at its final position or at the top of the excavation and then descended. In the latter case, the excavation and steel arrangement operations are independent and may become a more industrialized process. The pedestal framework acts at the same time as brace positioning template.

Stage 3: Precast braces casting (3 braces per round and day)
Molds can be stacked at some existing facility in the vicinity of the WTG or preferably within it, as the system doesn’t need high-tech facilities. Every day the sequence in working sequence will start by demolding the previous day casted braces, going then to cleaning the molds, putting in the reinforcement and post-tensioning steel, finally casting a new brace.

Stage 4: Central ring excavation
The process has no significant differences when compared with a conventional wall execution.

Stage 5: Upper slab excavation and backfilling
Very light backfilling requirements needs are asked for the filling as the density considered in the calculations is very low, from the safety side, so that not delaying the process.

Stage 6: Brace positioning
Post-tensioning works are carried out with conventional, commercial and worldwide available systems, requiring just a 2-3 hours time per foundation.

Stage 7: Lower slab, edge beam and central pedestal are casted
In this stage lower slab, edge beam and central pedestal are casted.

Stage 8: Final arrangement and reinforcement positioning

Conclusions
This foundation solution has proved to reduce the Cost of Energy in a significant way by means of significant cost savings between 30% and 55%, depending on the specific case comparing to conventional solutions, and providing a potential increase on energy production from 1.5% to 2.5% due to the increase, up to 6 meters, of the tower-foundation connection position. Some examples of its implementation are:

References